Discussion of the Deformation of a Circular Hole in Thin Ductile Materials with Respect to Its Strain Hardening Exponent

by Akio TAKIMOTO, Muneyoshi FUJIWARA and Susumu OCHIAI

The growth of a circular hole in thin sheet material and its fracture mechanism were investigated with respect to its strain hardening exponent under a tensile test to obtain basic knowledge about void growth and its fracture process in ductile material. The growth shape of the hole was measured exactly, and its deviation from an ellipse was found to be less than several percent. The axial ratio and areal ratio increase almost linearly with the plastic strain before a crack is formed. The growth rate of $d(a/b)/d\varepsilon(a, b$; major and minor semi-axes of the ellipse, ε ; strain) is shown to increase with a decrease in the strain hardening exponent. The growth rate is larger the bigger the pre-strain and, accordingly, the fracture strain is smaller the larger the latter. The results of the finite element method in a plane stress condition give good agreement with the experimental results. The theoretical relations for a plastic material by McClintock are also fairly consistent with the above results.

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Dynamic Stress Analysis of A Three-Dimensional Solid Body (Dynamic Stress Concentration Factor Around a Spherical Cavity in a Cylindrical Bar)

by Masakatsu SUGIURA and Yutaka TAKAGI

The reflection and interference of stress-waves play important roles in dynamic cases. It is very desirable to study the time variation of the stress distribution, and especially the value of dynamic stress concentration factors, in three-dimensional solid bodies. Hence, we have analyzed the stress propagation and the dynamic stress concentration phenomena around a spherical cavity in a cylindrical bar by utilizing the strain gauge method, the dynamic photoelastic method and also the finite element method. Emphasis was laid on the dynamic stress concentration analysis of bodies with inner cavities such as those often found in welded parts or castings. The simulation was achieved by using test models of composite specimen geometry in which a spherical cavity was introduced by a variation of the sandwich method. We found that the three-dimensional dynamic stress concentration factors obtained by the present three methods are all near the static stress concentration factors already reported for similar specimen geometries.

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Bending Problems of Annular Plates (2nd Report, The Case of an Eccentrically Concentrated Load and an Asymmetrical-Linearly Distributed Load)

by Minoru HAMADA, Yutaka INOUE*, Yoji SHIBUTANI** and Yoshitaka MORISAWA**

This research treats two problems related to the bending of an annular plate. The first problem is that of an annular plate subjected to an eccentrically concentrated load. This problem is solved by our method, proposed formerly, for the bending problem of a circular plate with one or two eccentrically situated circular holes with free edges. The calculated results for eight cases of boundary conditions are indicated in diagrams. The second problem is that of an annular plate subjected to an asymmetrical-linearly distributed load. This problem is solved by the method of superposition, and correct solutions of closed forms are obtained for eight cases of boundary conditions.

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On the Thermal Stresses of an Infinite Plate with Two Circular Inclusions Under a Steady Temperature State (Case of an Infinite Plate Containing a Pair of Heat Sources)

by Syunsuke SHIOYA

In this paper, we consider the problem of thermal stresses in an infinite plate with two circular inclusions. The steady state of temperature is induced by a pair of heat sources (positive and negative sources) placed on the x-axis. The analysis is developed by Airy's stress function in the case of generalized plane stress and by applying the bipolar coordinates. The method of perturbation is adopted for the determination of the unknown coefficients involved in the solution. Numerical calculations of the stress distributions along the main parts of the infinite plate and the inclusions are worked out in some detail. The maximum stresses on the common boundaries are also calculated and compared with the available results.

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Transient Thermal Stresses in a Circular Cylinder with Constrained Ends

by Takahito GOSHIMA and Kaju MIYAO

This paper deals with the transient thermal stresses in a finite circular cylinder constrained at both end surfaces and subjected to axisymmetric temperature distribution on the lateral surface. The thermoelastic problem is formulated in terms of a thermoelastic displacement potential and three harmonic stress functions. Numerical calculations are carried out for the case of a uniform temperature distribution on the lateral surface. The stress distributions on the constrained end and the free suface are shown graphically, and the singularity in stresses appearing at the circumferential edge is considered. Moreover, the approximate solution based upon the plane strain theory is introduced in order to compare the rigorous one,

and it is considered how the length of the cylinder and time affect the accuracy of the approximation.

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Model and Spectrum Analysis of an Uneven Road Surface by Means of the Two-Dimensional Filtered Poisson Process

by Xiang Wei ZHANG and Shigeru NAKAGIRI *** An attempt is made to develop a model of uneven road surface on the basis of the two-dimensional filtered Poisson process in order to obtain the power spectra to be employed as the input for structural analysis of automobiles. Double sinusoidal waves are used as the shape function, whose number of the occurrence, amplitude and half wave length are random variables of the Poisson process. The power spectra and coherence function are obtained analytically by the use of the said shape function. Numerical examples show that the Poisson process can simulate the road surfaces referred to in the ISO DP 8608 by means of the proper choice of process parameters and that the coherence function regarding the right and left wheels is small in the case of the isotropic and homogeneous process.

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Axisymmetrical Impulsive Responses of an Infinite Circular Cylindrical Shell Filled with Liquid

by Sadayuki UJIHASHI, Hiroyuki MATSUMOTO, Ichiro NAKAHARA and Masayuki SHIGETA In this paper, dynamic interaction phenomena on solid and liquid interfaces are discussed. Axisymmetrical responses of an infinite circular cylindrical shell perfectly filled with liquid are analyzed, based on Flügge's theory for a circular cylindrical shell and the potential theory for the ideal fluid under conditions of the impulsive external band pressure given on the outer surface of the shell. The deflection and the moment of the shell and the pressure in the fluid are evaluated by using the numerical inversion of the Laplace transformation method. The approximate solution for the shell with an equivalent mass on it is analyzed and is evaluated, based on the solution for the solid and liquid interaction.

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The Relation Between the Impact Load History and the Impacted Point on a Cantilever Beam

*by Hiroyuki MATSUMOTO *, Toyomi MIYAGAWA**, Sadayuki UJIHASHI** and Dong-Yul YANG* In this paper, the relation between the impact load history and the impacted point on a cantilever beam is theoretically investigated and the results are verified by the experiments. In the theoretical analysis the impact load history is obtained by the use of the classical beam theory and Hertz's law of contact under the condition that steel bars or balls strike a semi-infinite beam in the vicinity of the free end. In the experiment the impact load history is measured by the use of a piezoelectric transducer mounted on the cantilever beam, or by a strain gauge cemented on the bar. As a result, it is shown that the impact load history is much affected by the distance from the free end to the impacted point, and the theoretical results are in good agreement with the experimental results.

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Circular Hydraulic Bulge Deformation of Zn-Al Eutectoid-Base Alloys and Superplasticity-Related Region

by Yoshinobu MOTOHASHI and Takao SHIBATA A circular hydraulic bulge test of Zn-Al eutectoid-base alloys having various initial grain-sizes has been carried out at different temperatures. The experiment has been performed to find out the region of a combination of temperature, stress and grain-size, which is closely related to superplasticity, where a large deformation arises under an equi-biaxial tensile stress condition. Then the superplasticity-related region obtained has been compared with that obtained by a uniaxial tension test. It appears that the extent of grain-size where superplasticity arises under biaxial stress is wider than that observed under uniaxial stress. The values of the bulge factor are always larger than 1.0 within the superplasticity-related region. The microstructure near a polar region of the bulge after deformation is very similar to that observed in the tension test.

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Analysis of Forward Extrusion by the Grid Method (Application of Lagrange's Method of Undetermined Multipliers)

Masakazu TOMITA The usual grid method has such serious defects that the stress solution depends on the path for numerical integration of stress derivatives. In this study, a new method which derives stress distributions independently of their numerical integrations is devised for steady state axisymmetric extrusion; that is, on every small plastic region the mean stress distribution is given by a second order equation with respect to r and z, and considering the continuity of the mean stress, the unknown coefficients of all of those assumed equations are evaluated with the least squares method of mean stress derivatives. The above Lagrange's method is applied to this procedure, together with the unit division method, for shortening the calculation time, in a way which is similar to that used in the finite element method. As a result, the stress solutions can be uniquely determined in a short calculation time.